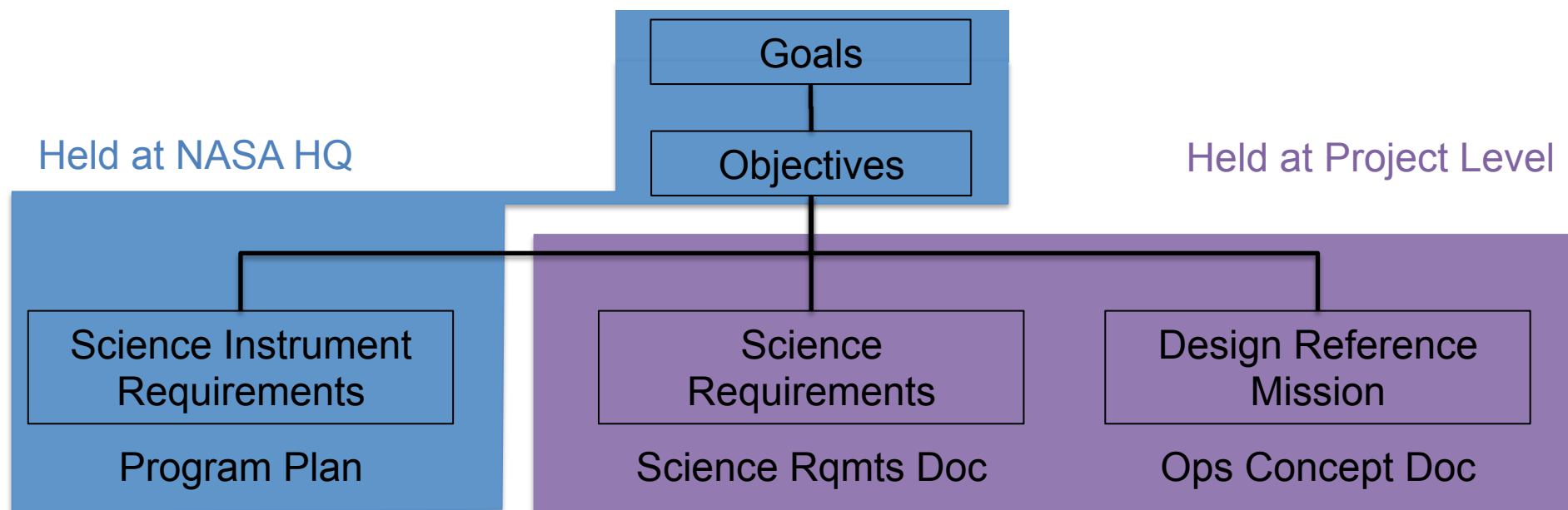# Level 1 Requirements Discussion

Mark Melton

Level 1 Requirements Progress

- Since the last discussion of Level 1 requirements with the SDT, the Study Office has been working with NASA HQ to take the past inputs you've provided on requirements and word them in a manner that is consistent with HQ needs.

- At Level 1, HQ would like requirements that:
  - Are written at a high enough level to provide the Study Office with flexibility in design trades underlying them
  - Are written so that the designed mission can produce test data on the ground that can be vetted quantitatively against the requirement
  - Feature in only one BSR; aggregated instrument requirements from all science cases can flow into them.

Current Draft

- We understand the concerns that have been expressed about not specifying observing time or sizes of surveys in the requirements and we are trying to address while working within the guidelines from HQ.
  - So, we've described the survey envisioned that would meet the science goal for each program.
  - This is provided in the paragraphs defining the science programs that drive the Objectives.
- There are still open items that need some work. HQ provided some feedback on the current draft that we need your help in addressing.
- Additionally, all numbers are considered TBD and need to be validated.

WFIRST Top Level Science Requirements

Held at NASA HQ

Held at Project Level

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                        ┌──────────────┐
                        │    Goals     │
                        └──────────────┘
                        ┌──────────────┐
                        │  Objectives  │
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Science Instrument Requirements	Science Requirements	Design Reference Mission
Program Plan	Science Rqmts Doc	Ops Concept Doc

The WFIRST Top Level Science Requirements are captured in two locations. The Program Plan contains the Science Objectives and the Science Instrument Requirements and is maintained at NASA HQ. The Science Requirements Document captures the Science Requirements and contains the detailed description of the flowdown from the Science Objectives to both the Science Instrument Requirements and the Science Requirements. Together, the Science Instrument Requirements, the Science Requirements, and the Design Reference Mission work to validate the WFIRST mission will meet the Science Objectives outlined in the Program Plan.

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Dark Energy Goals & Objectives

- Goal
  - WFIRST will characterize the history of cosmic acceleration, with the goals of determining whether it is caused by a new energy component of the universe or by a breakdown of general relativity on cosmological scales, and whether the cause has been constant in time or evolving over the history of the universe.

- Survey Envisioned
  - WFIRST seeks to measure the spectra, light curve, fluxes, and redshifts of 2000 Type Ia supernovae over the redshift range of $z = 0.2$ to 1.7 in the supernova survey, the positions and redshifts of 20 million emission line galaxies in the redshift range of $z = 1 - 2$ in the galaxy redshift survey, and the shapes and redshifts of 500 million galaxies in the redshift range of $z = 0 - 2$ in the weak lensing imaging survey.

- Objectives
  - Measure the expansion history of the Universe with sub-percent precision over the redshift range $z = 0$ to 2 by combining three or more measurement techniques (BAO, SNIa and WL) to provide coverage and independent metrics across the full redshift range.
  - Measure growth of structure with sub-percent precision over the redshift range $z = 0$ to 2 combining at least 2 techniques (WL and RSD) to provide coverage and independent metrics across the full redshift range.

Dark Energy Requirements

- **BSR1:** WFIRST Wide-Field Instrument (WFI) shall measure positions and redshifts of emission-line galaxies in the redshift range z = 1 - 2 with a position accuracy of TBD and a redshift accuracy of 1 part in 1000 and a minimum detectable point-source line flux of 0.5×10^{-16} ergs/cm2/s at 7σ significance.

- **BSR2:** WFIRST WFI shall measure shapes of galaxies at z=0-2 in at least 2 bands and fluxes in at least 4 bands for photometric redshifts with photometric accuracy of TBD and with shape measurement systematics contributing less than 0.1% uncertainty to the cosmic shear signal.

  - Can we rewrite this is such a way as it doesn't refer to the cosmic shear signal since we don't control it?

- **BSR3:** WFIRST WFI shall measure the spectra, light curve, fluxes, and redshifts of Type Ia supernovae with 5 day cadence over a redshift range of z = 0.2 to 1.7 with observational errors and calibration uncertainties that keep the aggregate precision of the data set better than 0.2% in distance.

  - How can we capture a sensitivity required with out referring to the aggregate precision?

Exoplanet Microlensing Goals & Objectives

- Goal
  - The goal of the WFIRST exoplanet microlensing survey is to understand how planetary systems form and evolve and to determine the makeup of the cold, outer regions of planetary systems.

- Survey Envisioned
  - WFIRST seeks to monitor a large number of systems for exoplanets, providing a yield for reasonable assumptions about planet frequency of at least 3000 planets with mass above 0.1 Earth masses and semi-major axes greater than 1 AU, with at least 10% of these planets having the mass of the Earth or less. WFIRST also seeks to derive host star masses for at least half of the detected planetary systems.

- Objective
  - Complete the statistical census of planetary systems in the Galaxy, from the outer habitable zone to free floating planets, including analogs to all of the planets in our Solar System with the mass of Mars or greater.

Exoplanet Microlensing Requirements

- **BSR4**: WFIRST WFI shall measure the light curve and fluxes of microlensing events in the galactic bulge region to detect planets as low as 0.1 Earth masses at separations down to 1 AU.

  - Can we calculate the flux density required to measure 0.1 M_Earth at 1 AU and use instead?

- **BSR5:** WFIRST WFI shall measure the masses of at least TBD% of the microlensing planet host stars to a precision of at least 20%.

Exoplanet Direct Imaging Goals & Objectives

- Goal
  - The goal of the WFIRST exoplanet direct-imaging survey is to understand the compositions and atmospheric constituents of a variety of planets around nearby stars and to determine the properties of debris disks around nearby stars and to understand how planets interact with these debris disks.

- Survey Envisioned
  - WFIRST seeks to characterize photometrically at least a dozen known radial velocity planets of at least 4 Earth radii with minimum star-planet separations of TBD, characterize spectroscopically half of these, and search for other planets around nearby (~10 pc) stars. Additionally, WFIRST aims to search for low surface density circumstellar disks around several dozen nearby stars as well as image the inner regions of known bright disks.

- Objective
  - Discover new planets and disks around nearby stars and characterize these new and previously known planets and disks by means of high-contrast imaging and spectroscopy and develop coronagraph technology to enable this science and as an investment for future missions.

Exoplanet Direct Imaging Requirements

- **BSR6:** WFIRST Coronagraph shall directly image exoplanets around nearby stars, and carry out color photometry measurements in the spectral range about 400-1000 nm, for planets as small as 4 Earth radii.
  - Replace the minimum planet size with a contrast and IWA per HQ recommendation
- **BSR7:** WFIRST Coronagraph shall spectroscopically characterize planets by measuring continua and spectral absorption features over the wavelength range from about 600 – 950 nm with resolution about 70.
- **BSR8:** WFIRST shall be capable of detecting a disk with 10 times our solar system's zodiacal flux in or near the habitable zone (~1 AU) of a solar-type star at a distance of 8 pc at 450 nm.
  - Is this identical in requirement to BSR6? If so, we should insert the aggregated instrument requirements into BSR6.

Guest Observer Goals & Objectives

- Goal
  - WFIRST will have a robust Guest Observer program for wide-ranging astrophysical investigations using the wide field and coronagraph instruments.

- Objective
  - A substantial fraction of the WFIRST mission lifetime will be dedicated to a peer-reviewed Guest Observer program. This program will allow for a broad range of scientific studies of astrophysical targets in our Galaxy and external galaxies, to be observed over the full sky and at an adequate frequency through each year of the mission lifetime.

Path to Closure

- We really want to complete this initial activity on the Level 1s by mid April so the SDT can focus on the more detailed Level 2 requirements.

- We need the SDT to review the latest draft and provide feedback on the requirements and the comments from HQ.

- If you are unhappy with the way a requirement is written, suggest an alternate version, but please work to ensure they meet the HQ guidelines from slide 2.

- Would appreciate feedback within a week (4/8)

- We're available to discuss during breaks & splinters